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Case 162-CIP-Div2-U.S.(RCE)

Specification Amendments

[0002] This invention relates to apparatus for softening a selected portion of a steel metal object by heating and will be described in the context of eliminating or at least drastically reducing the cracking which today frequently occurs at the junctions of the body and shank of ferrous alloy die blocks and similar parts.

[0016] In another embodiment of the invention the a die block after hardening but either before or after a shank is formed in the back side (i.e.: the non-working surface) of the die block is subjected to infrared heat. The infrared heat is preferably generated by tungsten halogen lamps which are arranged to direct the radiant energy at the surface to be treated. While no limits on the length of the waves of the electromagnetic spectrum have been positively established, good results have been obtained with short wave radiation, i.e.: 0.78 to 2.0 μm .

[0030] Referring now to Figure 5 an induction heating means which may be referred to as a paddle is indicated generally at 35. Paddle 35 is an induction heating coil system composed of a length of continuous, hollow copper tubing, indicated generally at 36, said tubing having an inlet 32, an entry run 37, a bend 39, a return run 40 and an outlet 41. It will

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be seen that entry run 37 and return run 40 are parallel to one another, and that these heating elements are substantially equally spaced from one another and lie in a common flat plane.
The hollow, fluid tight tubing is enclosed in a steel jacket, indicated generally at 42, whose width

[0032] A through hardened die block is indicated generally at 50 resting upon the right end portion of paddle 35. The die block, which, in this instance, does not have a shank formed in it, is defined by front side 51, rear side 52, left edge 53, right edge 54, shank portion 55 and body portion 56. As can be appreciated from Figure 3, the entire flat surface area of the shank portion bottom 55 of block 50 is in surface abutting contact with the top surface 33 of the paddle 35.

[0044] The infrared furnace of Figure 6 is a flat panel cold wall furnace; i.e.: only the selected portion of the workpiece, here the body-shank junction portion 87, see Figure 7, of the die block 88, is heated to the desired temperature. The furnace includes structural heat blocking members comprising a hood, indicated generally at 81, a top 82, depending edge walls 83, 84, tungsten halogen filament heating elements 85, and, in this instance, cooling means indicated at 86, all of which confine the heat from the electric heat source to the body-shank junction portion of the die block. It will be seen that the heating elements 55 are

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parallel to one another and are equally spaced from one another as they lie in a common flat plane. The furnace utilizes 100 W per linear inch elements 85, which function as means for subjecting said selected portion to heat energy derived from said source 85 of infrared heating. Due to the low thermal mass of the heating elements 85, the furnace is capable of its full heat flux in approximately 2 seconds after start-up. Also, due to its cold wall design, the furnace cools extremely quickly. The furnace includes conventional means such as any simple raising and lowering linkage, not shown in detail for purposes of clarity, for maintaining said selected portion 87 and said source of infrared heating 85 in fixed relationship to one another during subjection of said selected portion 87 to said source of infrared heating 85.

[0045] In one demonstration, approximately 12 infrared heat treatments were performed on an 18- x 22- x 12-in.-thick steel block instrumented with control means represented by the 12 thermocouples in Figures 6 and 7 which were located at various depths and locations throughout the block. A maximum of 51.2kW was utilized on the top surface (22 by 18 in.) of the shank portion of the steel block with an infrared flat panel for 47 minutes prior to cutting back the power by adjustment of the control means to maintain the surface temperature of the block at 1320°F (716°C). After 1 hour and 18 minutes, the furnace had to be held at 21.4 kW to maintain the required given temperature; that is, to limit

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the amount of heat energy which impinges onto the uncovered flat surface at the shank portion to an amount which softens only the shank portion.

[0047] The uncovered block was initially heated with a heavy oxide scale in order to observe the effects of this heavy loose scale on the infrared heating. A second experiment was performed with the surface of the uncovered block ground revealing unoxidized steel. It was observed that this had little effect on the overall heating due to a couple of factors. The furnace was positioned perpendicularly over the flat surface of the shank portion of the steel block as shown in Figure 7 so that the flat surface of the shank portion of the steel die block is located in unobstructed facing relationship to the heating elements 85, and so that any light not absorbed by the block would be reflected back by the highly nonabsorbing body top 82 and elements 85 reflected back to the uncovered steel block. Thus the heat from the heat source, i.e.: heating elements 85, impinged uninterruptedly directly onto the uncovered flat surface of the shank portion of the die block. The surface of the steel block exceeded 752°F (400°C) in less than 10 minutes which is the temperature at which oxidation of the steel will occur and the surface will absorb over 90% of the incident light.

[0050] In a subsequent procedure, a hardened metal block was treated to preferentially soften the back 2.5 in. Three thermocouples were attached to the block to monitor

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temperature during the softening process at the surface, 2.5 in. down the side and on the back side. This block was about two-thirds the size of the block utilized for all of the temperature profiling of Figure 7. The block with a 2.5-in. insulation wrap was heat treated at 1320°C for 3-1/2 hours with the infrared furnace, and the temperature profile is shown in Figure 8.

[0051] The foregoing results indicate that infrared heating, like the induction heating system of Figures 2, 3 and 5, makes possible the lowering of the hardness level of the shank portion to a hardness level below the body portion of the die block which lies beneath the shank portion; in other words a differential hardening within the body of the workpiece, here a die block, sources can effectively reduce the hardness of a prehardened die block. The block hardness was 2.95 BID (429 HB). To verify the softening effect of the infrared heat source, the following procedure was used: (1) .5 in. of material was removed, and (2) Brinell hardness tests were taken over the surface using a 2- by 2-in. grid. This procedure was performed until the hardness was measured at a distance of 2 in. below the heated surface. As can be seen in Figure 9, the hardness 2 in. below the surface is an average of 3.26 BID (350 HB). The "crowned" shape of the hardness distribution could be due to the loss of infrared energy from the sides of the block or from the natural hardness distribution from edge to edge of the block.